Response to Reviewer #1:

We gratefully thank the editor and all reviewers for their time spent making their constructive remarks and useful suggestions, which have significantly raised the quality of the manuscript and have enabled us to improve the manuscript. Each suggested revision and comment, brought forward by the reviewers was accurately incorporated and considered. Below are the comments of the reviewers and response point by point and the revisions are indicated. We use different colored fonts to distinguish between responses to reviewers and the revised sections of the manuscript.

1. Responses to reviewers are highlighted in blue.

2. *Revised sections of the manuscript are highlighted in red.*

Comment 1: Thank you for the careful updates and consideration of the review comments. I really appreciate the updated comparison to the observations of isoprene especially moving to consistent time periods between the model and observations. This update gives the reader higher confidence in the model improvements.

Reply: We sincerely thank the reviewer for their positive feedback and for recognizing the updates made to the manuscript.

Comment 2: There are still several issues described below to fix too. Please be very careful when describing the statistics in Tables 2, 3, and 4. I noticed several inconsistencies. Also please include a plot for the isoprene comparisons to observations. The monthly average statistics while useful are not sufficient to show your model biases for this important variable considering that your entire study is on BVOC emission updates:

Reply: Thank you for your valuable feedback. We have carefully reviewed and addressed the inconsistencies in the statistics presented in Tables 2, 3, and 4. Additionally, we have included a plot comparing isoprene (ISOP) concentrations to observations, as per your suggestion. We agree that the monthly average statistics alone may not fully capture the model biases for this key variable, and the added plot will provide a clearer picture of the model's performance regarding BVOC emissions.

Comment 3: Line 33 – Please add "mean biases" instead of just "biases" to be more specific here. Please, double check the rounding and negative or positive sign of these numbers and be more specific here on where they are from? Looking at the text, I believe these numbers are taken from both Table 3 (monthly average for all sites) for NO_2 and Table 4 (monthly mean for just the city center but not considering the negative sign) for MDA8 O_3. Please, be more specific here as the reader would assume that NO_2 and O_3 here are for the same region, hourly values, and both have positive biases, but they are for different regions, metrics, and different signs for the biases?

Reply: Thank you for your valuable comment. We have clarified the description of the biases in the text to ensure better specificity. The updated sentence now reads:

The study shows improvements in simulation mean biases for MDA8 O_3, from -3.63 to -0.75 ppb in the city center region.

Additionally, we have reviewed and verified the rounding and sign of the numbers to ensure accuracy. As per your suggestion, we have also made it clear that the biases are from different regions and metrics.

Comment 4: Line 263 – Please consider re-wording this statement. I'm not sure what you mean: "BVOCs are the major sources of ISOP and monoterpene (TERP)".

Reply: We have reworded this statement as follows:

ISOP and monoterpene (TERP) are the major species of BVOC emission, making their concentration assessment a feasible and convincing method for indirectly validating the accuracy of BVOC emission estimates.

Comment 5: Table 2 - It would be particularly useful for the reader to include a plot of the observation to model comparisons for isoprene and not just the monthly averaged statistics shown in Table 2. This could be a simple diurnal plot of the month of September like Figure S5a or a scatter or box and whisker plot. The R2 values indicate correlation is only okay, so having a plot to show this variability or spread in the obs and model is very useful rather than just looking at averages. Also considering the authors focus in on a couple of high ozone episodes understanding how the model compares with observations for isoprene on those high ozone days would also be quite useful. I highly recommend adding a plot like this to your paper even if just in the supplement.

Reply: Thank you for the helpful suggestion. We have now added a plot (Figure S4) comparing observations to the model for isoprene, as recommended.
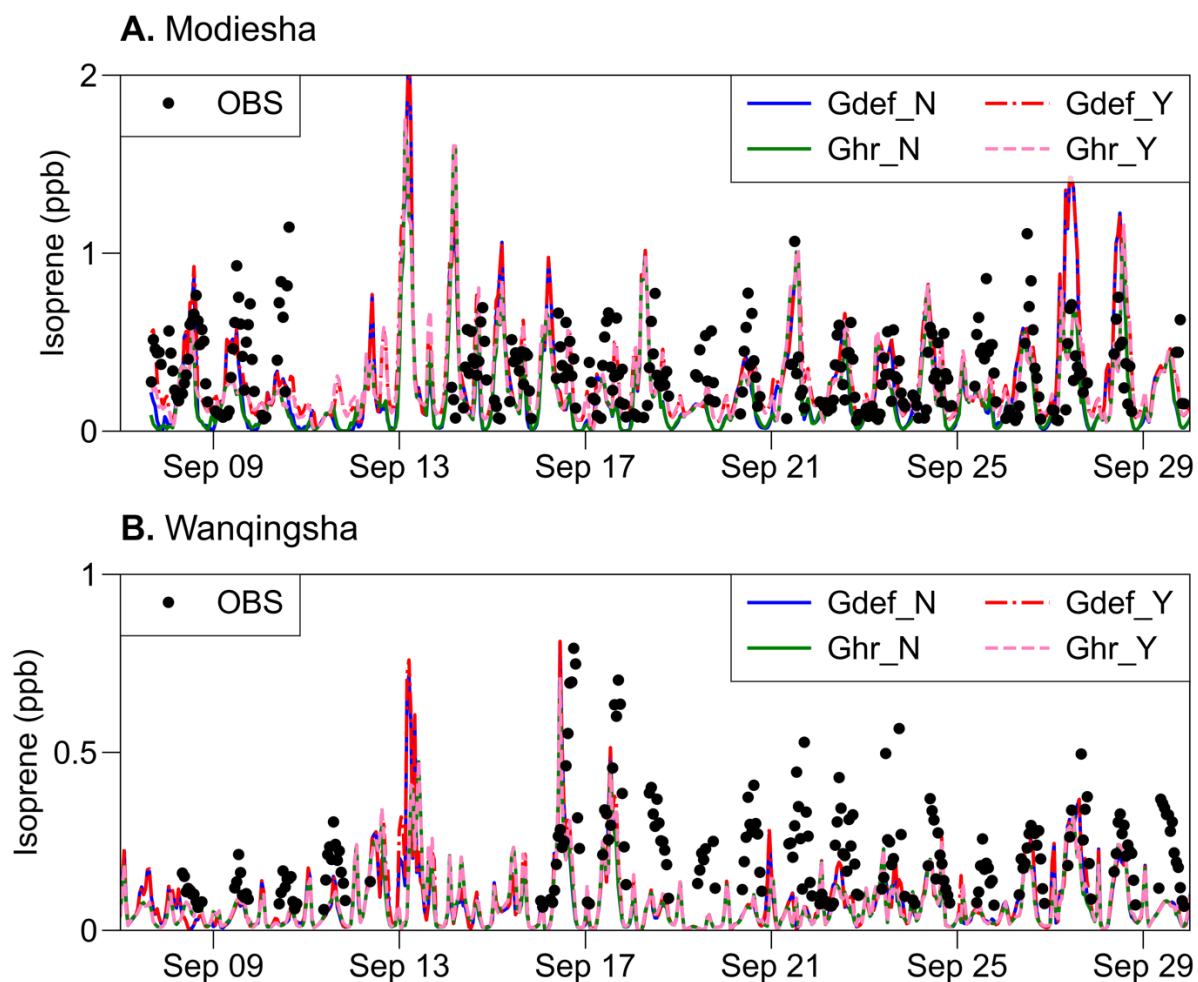
Figure S4 The hourly variations of observed and simulated ISOP concentrations for different cases at Modiesha (a) and Wanqingsha (b) sites during September 2017.

In Section 3.1:

Additionally, all cases successfully capture the hourly ISOP concentrations when compared to observations at both the Modiesha and Wanqingsha sites (Figure S4).

Comment 6: Line 294 – typo reasonably should be reasonable.

Reply: Thanks for this suggestion. We have changed "reasonably" to "reasonable".

As shown in Table 3, the modeling performance for all cases are reasonable, albeit with some degree of underestimation.

Comment 7: Line 298 – Add what variable and metric you are comparing here. Assuming MDA8 ozone.

Reply: Thanks for the nice suggestion. We have reworded this sentence as follows:

Specifically, the MB values of MDA8 O_3 decrease from -2.16 ppb in the Gdef_N case to -0.26 ppb in the Ghr_Y case, demonstrating that incorporating UGS-BVOC, UGS-LUCC, and their combined effects can enhance the accuracy of predicted daytime O_3 concentrations.

Comment 8: Line 305 - Can you rephrase this sentence? I'm not sure what you mean. "The improvement in NO2 predictions is attributed to the increased involvement of NO_2 in O_3 formation caused by the UGS-BVOC emissions, which reduces simulated NO_2 concentrations and narrows its bias against the observation.

Reply: Thanks for the valuable suggestion. We have rephrased this sentence as follows:

The improvement in NO_2 predictions is attributed to the inclusion of UGS-BVOC emissions in the CMAQ model, which enhances NO_2 involvement in O_3 formation. This process leads to lower simulated NO_2 concentrations, reducing the MBs compared to observations.

Comment 9: Line 314 - typo remarkable should be remarkably

Reply: Thanks for the careful checking. As suggested by another referee We have changed "remarkable" to "significantly" here.

These results indicate that the inclusion of UGS-BVOC emissions significantly influences MDA8 O_3 and hourly O_3 concentrations in the city center region and this effect, primarily …

Comment 10: Table 4 and line 318 - 319 – The table says -3.627 and you say -3.62 in the text. How are you rounding this? Please be consistent. Also be consistent with this negative number in the abstract and conclusion as specified above and below. I do not see -1.18 ppb in the table for city center hourly ozone, please double check this number? On line 318, please double check which cases these numbers are comparing against. The way you have written this sentence, I would assume you are comparing Gdef_Y and Gdef_N cases, but that's not where the numbers are coming from?

Reply: We sincerely thank the reviewer for pointing out this inconsistency. In the original manuscript, the value in the text (-3.62) was rounded differently from the value in Table 4 (-3.627). To ensure consistency and accuracy, we have revised the text to reflect the value -3.63, which is the correctly rounded value of -3.627 to two decimal places.

Upon careful review, we identified an error in the originally reported value of -1.18 ppb for city center hourly ozone. The correct value, as shown in the table, is -1.52 ppb. We have updated the text to reflect this correction.

We sincerely apologize for the oversight and appreciate the reviewer's diligence in helping us improve the accuracy of our manuscript.

The reviewer is correct that the original sentence incorrectly implied a comparison between the Gdef_Y and Gdef_N cases. In fact, the numbers are derived from a comparison between the Ghr_Y and Gdef_N cases, which accounts for the integration of both UGS-BVOC emissions and UGS-LUCC. We have revised the text on line 318 to clarify this comparison and ensure accuracy. The updated sentence now reads:

By integrating the UGS-BVOC emissions and UGS-LUCC into the models (comparing Ghr_Y and Gdef_N cases), the MBs of MDA8 O_3 and hourly O_3 in all regions, including a notable improvement in the city center region from -3.63 to -0.75 ppb and -2.86 to -1.52 ppb, respectively, is reduced.

Comment 11: Line 340 – How are you rounding these numbers? Please, make sure they are just rounded versions of what is in the table or use the exact same numbers.

Reply: We thank the reviewer for pointing out this inconsistency. To address this, we have revised the text on line 340 to ensure that the rounded numbers in the text align with the values in the table. Specifically, we have applied consistent rounding rules (e.g., rounding to two decimal places) to the numbers in the text, ensuring they are accurate representations of the values in the table. This change improves clarity and consistency throughout the manuscript. We appreciate the reviewer's attention to detail, which has helped us enhance the precision of our presentation.

Regionally, the suburban region registered the highest UGS-BVOC emissions in Guangzhou, peaking at 367 Gg. This is followed closely by the rural and city center regions, recording emissions of 174 Gg and 126 Gg, respectively.

Comment 12: Line 545 – Typo make sure to translate the Chinese characters here for final version.

Reply: Thanks for the careful checking. We have deleted these Chinese characters. The revised version here is as follows:

Table 6 presents the overall results for the impacts of UGS-LUCC and UGS-BVOC on MDA8 O_3 concentrations.

Comment 13: Line 614 – What do you mean by "baseline concentration of 0.35 ppb"? The observations are 0.34 in Table 2? But maybe you are referring to something else. Please double check and replace baseline with something more descriptive.

Reply: Thanks for this nice suggestion. We have rewritten this sentence as follows:

For instance, incorporating UGS-BVOC emissions results in an increase in ISOP concentration from 0.29 ppb to 0.35 ppb and from 0.23 ppb to 0.29 ppb under different land use cases (Gdef and Ghr), compared to a observed concentration of 0.34 ppb.

Comment 14: Line 618 – Should 3.62 here also be negative? Also see above should this be rounded differently to compare with the value in Table 4. Also, if this is MDA8 ozone, please add this here to be clearer.

Reply: Thanks for this valuable suggestion. We have rewritten this sentence as follows:

Secondly, this precise estimation of BVOCs and the consideration of UGS-LUCC has notably shifted the MB of MDA8 O_3 simulations from -3.63 ppb to -0.75 ppb in the city center region.

Comment 15: Figure S5a has ozone still in ug/m3 instead of ppb, which is hard for the reader to compare with Figure 7a, which is in ppb. It would be useful if these plots all used consistent units.

Reply: *We thank the reviewer for pointing out this inconsistency in the units used in Figure S5a. To ensure clarity and facilitate comparison with Figure 7a, we have updated Figure S5a to use consistent units, converting ozone concentrations from µg/m³ to ppb. This change aligns with the units used in Figure 7a and improves the readability and comparability of the results. We appreciate the reviewer's suggestion, which has enhanced the consistency of our presentation.*
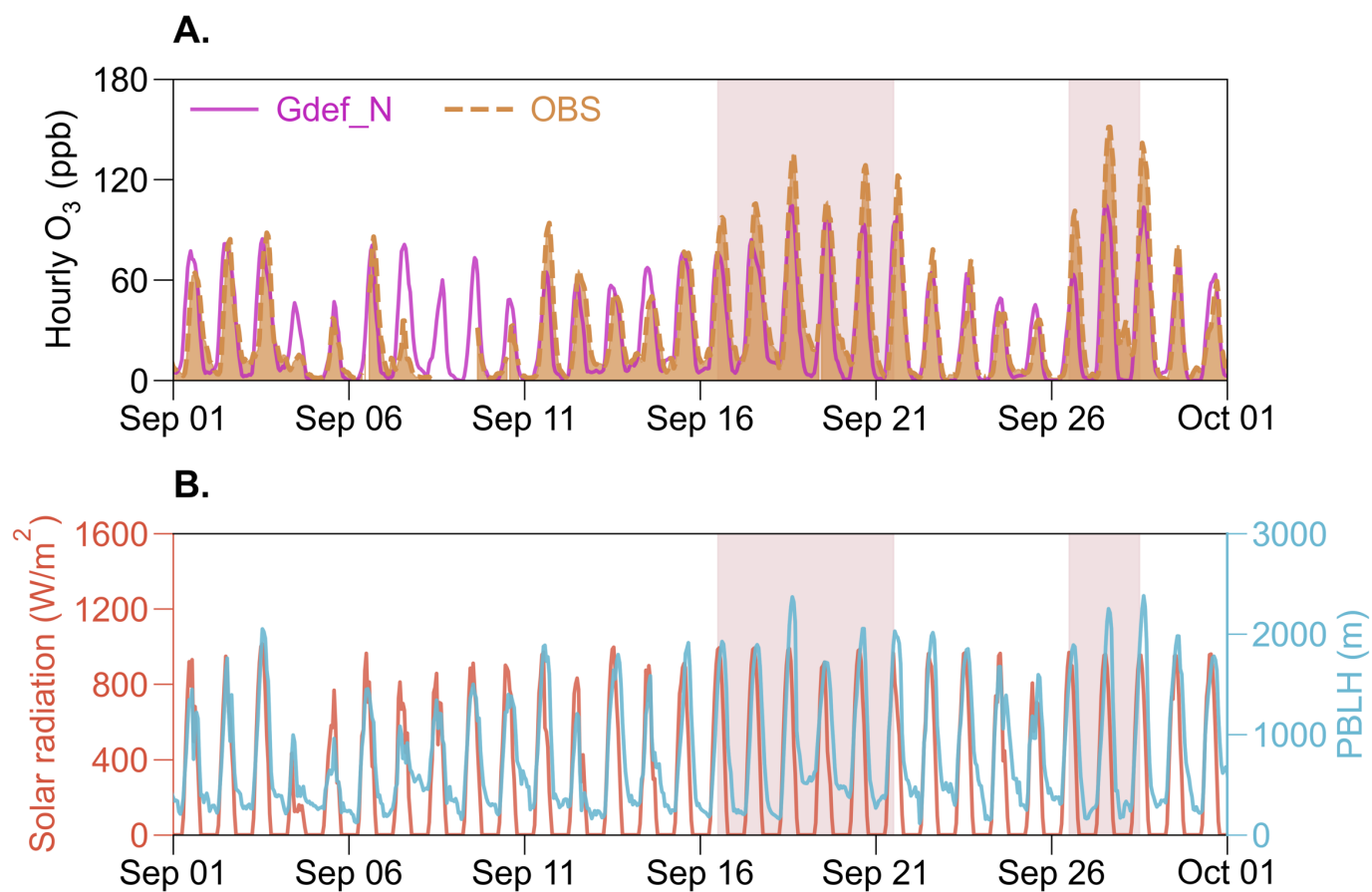
Figure S5 The comparison between the average hourly O3 values from simulation and observation (A). And the relative grid average values of solar radiation and PBLH (B).

Response to Reviewer #2:

We gratefully thank the editor and all reviewers for their time spent making their constructive remarks and useful suggestions, which have significantly raised the quality of the manuscript and have enabled us to improve the manuscript. Each suggested revision and comment, brought forward by the reviewers was accurately incorporated and considered. Below are the comments of the reviewers and response point by point and the revisions are indicated. We use different colored fonts to distinguish between responses to reviewers and the revised sections of the manuscript.

1. Responses to reviewers are highlighted in blue.

2. *Revised sections of the manuscript are highlighted in red.*

Comment 6: The authors discuss the impacts of LUCC on temperature and solar radiation- the temperature "heat island" is well known but the impact on solar radiation is less clear. What are the processes in the model and are they realistic? By "urban region receives less solar radiation than other regions likely due to the shading effect of urban canopies" do you mean that you are using the ground surface temperature and light to drive BVOC emissions? The ground surface values are not the light and temperature that you should be using to drive the BVOC emissions. It should be the canopy light and temperature. Reassess whether the impacts you are seeing are influenced by the model is using the wrong light and temperature.

Reply: Thanks for this nice question. We don't mean that we used the ground surface temperature and light to drive BVOC emissions. MEGANv3.1 use the 2-m temperature variable from the WRF model to calculate the BVOC emissions, and the 2-m temperature in WRF can be affected by the shading effect.

RC's reply: Please address this with a sentence in the manuscript as other readers will also likely be confused.

Reply: We have added a sentence to Section 2.2.

It is worth noting that MEGANv3.1 uses the 2-m temperature variable from the WRF model to calculate BVOC emissions. Meanwhile, The MEGANv3.1 approach can calculate the emissions at each canopy level as the product of the emission factor and emission activity at each level.

Comment 7: Ozone responds to temperature for multiple reasons. Quantify the impact of BVOC emission response to temperature relative to these other reasons.

Reply: This is a valuable comment. However, we think this question beyond the scope of this study. Another study by our group (Li et al., 2024) demonstrated the responses of O_3 to temperature through multiple mechanisms, including changes in chemical reaction rates, BVOCs emissions, soil NO_x emissions, dry

deposition, PAN decomposition, and etc. The major one among all mechanisms varies in regions. Please refer to more information in this paper.

Li, S., Lu, X., and Wang, H.: Anthropogenic emission controls reduce summertime ozone-temperature sensitivity in the United States, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-1889, 2024.

RC's reply: You can refer to the Li et al. paper, rather than making these calculations, but you should still be able to make some statement in the manuscript regarding whether the BVOC is a major component of the temperature dependent VOC or not and point out that there are other components.

Reply: We have added some statement to Section 3.2.

Temperature-dependent BVOC emissions are among the well-known key temperature-dependent mechanisms influencing ozone levels, alongside other processes including changes in chemical reaction rates, soil NO_x emissions, dry deposition, and PAN decomposition, as demonstrated in Li et al. (2024).

Li, S., Lu, X., and Wang, H.: Anthropogenic emission controls reduce summertime ozone-temperature sensitivity in the United States, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-1889, 2024.

One final comment: The use of "remarkable" on lines 314 and 623 are not warranted. The original use of "significant" is OK or just don't have an adjective there. The use of "remarkable" on line 625 is OK and distinguishes this point from the other two.

Reply: We have addressed these suggestions.

Line 314:

These results indicate that the inclusion of UGS-BVOC emissions significantly influences MDA8 O_3 and hourly O_3 concentrations in the city center region and this effect, primarily…

Line 623 and 625:

The UGS-BVOC emissions have a significant impact on ozone concentrations, with increases ranging from 1.0-1.4 ppb (+2.3-3.2%) in the city center regions. However, when considering the combined UGS-LUCC and UGS-BVOC effects, the impact on MDA8 O_3 concentrations becomes remarkable, …